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Understanding the human factors contribution to railway accidents and incidents in Australia

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ABSTRACT

Forty rail safety investigation reports were reviewed and a theoretical framework (the Human Factors Analysis and Classification System; HFACS) adopted as a means of identifying errors associated with rail accidents/incidents in Australia. Overall, HFACS proved useful in categorising errors from existing investigation reports and in capturing the full range of relevant rail human factors data. It was revealed that nearly half the incidents resulted from an equipment failure, most of these the product of inadequate maintenance or monitoring programs. In the remaining cases, slips of attention (i.e. skilled-based errors), associated with decreased alertness and physical fatigue, were the most common unsafe acts leading to accidents and incidents. Inadequate equipment design (e.g. driver safety systems) was frequently identified as an organisational influence and possibly contributed to the relatively large number of incidents/accidents resulting from attention failures. Nearly all incidents were associated with at least one organisational influence, suggesting that improvements to resource management, organisational climate and organisational processes are critical for Australian accident and incident reduction. Future work will aim to modify HFACS to generate a rail-specific framework for future error identification, accident analysis and accident investigation.

1. Introduction

There is little doubt that human error contributes to the majority of incidents and accidents which occur within complex systems, including the railway system (e.g. Atkins, 2003; Gilchrist et al., 1990; Hall, 2003; Krokos and Baker, 2007; O'Hare, 2000; Shappell and Wiegmann, 1997). To prevent and/or reduce the number of accidents and incidents which occur we must work towards reducing human error or making the system/organisation more error tolerant. Human error and accident management involves the prevention of human errors, the recovery from errors, and the containment of the consequences that result from error occurrence (Cacciabue, 2005a). The first step in this process is error identification. Identifying the errors that frequently result in the occurrence of incidents and accidents may allow appropriate prevention and/or mitigation strategies to be developed.

No research to date has systematically examined the human error contribution to rail incidents and accidents in Australia. The predominant means of investigating the causal role of human error in accidents is the analysis of post-accident data (Shappell and Wiegmann, 1997). The primary aim of this study was to conduct an in-depth analysis of Australian rail incident/accident investigation reports for the purpose of identifying human errors. Human error identification (HEI) was achieved via the adoption of a HEI tool or error taxonomy. Taxonomies allow one to build a causal overview across a large number of incidents, enabling identification of dominant, recurring failure factors (Van der Schaaf, 2005), and causal and contributory factors over time (Thomas and Rhind, 2003). This paper represents our first attempt to apply error taxonomy to Australian rail incident and accident data. Human error here refers not only to operator errors, or errors and violations of those at the sharp end of a system, but also to those failures which occur at the blunt end of a system, associated with design, procedures, management and so on. These latter failures, latent failures of the organisation (Reason, 1990), are the product of errors of some individuals somewhere else in the system (e.g. designers, maintenance personnel, supervisors).

In this paper we firstly summarise relevant accident causation research, then outline the error framework selected. We then describe the data set on which the analysis is based, and then reveal the types and frequencies of errors that emerged from the analysis. We discuss the framework's effectiveness in capturing human error

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types and finally we discuss implications for system change following the identification of recurring failures. The paper concludes with an outline of future research.

2. Previous research: error and accident causation

Many models of accident causation have acknowledged the contribution of human error in accident occurrence (e.g. Embrey, 1992; Lucas, 1997; O'Hare, 2000; Reason, 1990). The most influential of these is that proposed by Reason (1990). Reason (1990) defined two broad categories of error: active and latent failures. Active errors, whose effects are felt almost immediately, are associated with the front-line operators of the system, while latent errors, whose adverse consequences may lie dormant within the system for a long time, only become evident when they combine with other factors to breach the system's defences (Reason, 1990). In a later version of his model, often referred to as the "Swiss Cheese Model", Reason (1997) included three system levels: unsafe acts, local workplace factors and organisational factors. An accident trajectory passes through the holes (which represent gaps in defences, barriers, safeguards and controls) in successive levels, resulting in an accident (Reason et al., 2006). These holes or weaknesses are caused by errors and violations of front-line operators but also errors of designers, managers, supervisors and maintainers (Reason, 1997).

Identifying what errors (both active and latent) contribute to accident occurrence can be difficult because there is no well defined start of the causal chain of an accident and exactly the same events can lead to widely different consequences (Rasmussen, 1987). It has also been suggested that there is little relationship between the magnitude of an error and the consequence of that error (Singleton, 1972). A variety of HEI tools/techniques have thus been developed to aid in error identification/classification, all comprising of at least one error taxonomy and several also including a human error quantification component (see Kirwan, 1994, 1997a,b for a review). Some of the more well-known techniques include the Technique for Human Error Rate Prediction (THERP), Human Hazard and Operability Study (Human HAZOP), Systematic Human Error Reduction and Prediction Approach (SHEPRA), Cognitive Reliability and Error Analysis Method (CREAM), the Technique for the Retrospective and Predictive Analysis of Cognitive Errors (TRACEr), and the Human Factors Analysis and Classification System (HFACS).

Many studies have identified human errors contributing to incidents and accidents in domains other than rail, like aviation and the chemical industry (e.g. Glendon, 1993; Kirwan, 1997b; Reason, 1990; Shorrock and Kirwan, 1999; Wiegmann and Shappell, 2003), but relatively few published reports have described specific error types associated with accidents and incidents in rail. In the UK, the TRACEr framework, initially developed for air traffic control, was recently modified to become a rail-specific HEI tool for train driving (RSSB, 2005) and is currently being used to identify and classify errors associated with rail incidents and accidents (e.g. Gilroy and Grimes, 2005). Other UK research has identified the types of communication errors involved in railway incident occurrence (Murphy, 2001; Shanahan et al., 2005). There has also been a large quantity of British research describing and classifying the nature of errors associated with one particular type of railway incident: Signals passed at danger (SPADs). SPAD-related errors have been categorised from a range of different perspectives including behavioural (e.g. Dray et al., 1999; Gibson, 1999; Lucas, 1989) and cognitive or information processing (e.g. Wright, 2000).

Analysis of rail incident/accident reports for the purpose of identifying recurring error types has also been conducted in Germany (e.g. Metzger, 2005) and in the US, where the Federal Railroad Administration (FRA) have recently reported that a small number of particular kinds of human errors (e.g. not properly lining switches, failure to lock and latch switches) accounted for an inordinate number of accidents (FRA, 2007).

There have been numerous international studies that have identified error types using an alternative approach to the analysis of incident and accident reports. These studies describe and analyse railway workers' tasks and consequently identify and classify worker errors and factors associated with those errors. The roles/tasks of train drivers (Bott, 1996; Buck, 1963; Cacciabue, 2005a,b; Crick, 2004; Little, 1996; Porter, 1992; Vanderhaegen, 2001), maintenance personnel (Farrington-Darby et al., 2005; Gibson et al., 2005), and signallers (Little, 1996; Sutton, 2003) have been reviewed and frequent error types for each role subsequently identified.

In Australia, no published work has identified or classified the human errors frequently associated with rail accidents and incidents. In the one reported Australian study investigating accident causation, the authors aimed to identify the latent failures (i.e. managerial deficiencies) most likely to be involved in accidents in the Australian public rail authority (Edkins and Pollock, 1996). Focus groups were initially held with drivers and management to identify railway problem factors influencing rail safety. A railway safety checklist, requiring respondents to rate the extent to which each factor had been a problem in carrying out their job, was then constructed and distributed to train drivers. Three factors were identified as the most serious problems, most likely to contribute to Australian rail accident occurrence: Staff attitude, operating equipment and maintenance (Edkins and Pollock, 1996).

3. Selection of an error framework

The type of framework used for error identification in accident analysis or investigation is dependent on the theoretical approach, or perspective, to human error adopted. Common perspectives on human error include cognitive, ergonomic, behavioural, individual, psychosocial, and organisational (see Wiegmann and Shappell, 2003 for a review). It has been shown that these error perspectives may not take into account the full range of errors associated with an incident or accident (Wiegmann and Shappell, 2003).

A framework capable of accounting for the full range of human errors possible in a complex system would be one that identifies all latent and active failures included in Reason's model of human error, as outlined above. The HFACS appears to be one such framework because it encompasses the entire range of system errors, from the sharp end (e.g. operator) to the blunt end (e.g. management). Developed by analysing an extensive set of aviation accident reports, it describes four levels of failure, as shown in Fig. 1: unsafe acts, preconditions for unsafe acts, unsafe supervision, and organisational influences (Shappell and Wiegmann, 2000a, 2003; Wiegmann and Shappell, 2003).

Following its development, HFACS was reportedly successfully applied to a wide range of aviation accidents (Gaur, 2005; Krulak, 2004; Pape et al., 2001; Shappell et al., 2007; Shappell and Wiegmann, 2000b, 2003; Wiegmann and Shappell, 2001). There has also been one published attempt to categorise contributing factors associated with railroad incidents/accidents using HFACS (Reinach and Viale, 2006a,b). The framework was initially modified to be more applicable to rail (HFACS-RR) and then applied to six incident/accident cases in railroad yard switching (Reinach and Viale, 2006a,b). This application however, was to a very specific rail incident type, and the framework is yet to be applied to a more general pool of rail incidents and accidents.

The US FRA has used HFACS-RR to develop a software tool (the Human Error Investigation Software Tool (HEIST)) to help the rail-